Instrument Development and Results of the Grain Velocimetry and Tomography Analysis System.
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Introduction: The Grain Velocimetry and Tomography Analysis System (GraVeTAS) is a laser-based nephelometry and anemometry instrument being developed at the Southwest Research Institute under the Exploration Science Pathfinder Research for Enhancing Solar System Observations (ESPRESSO) SSERVI node. The instrument (shown in Figure 1) samples the scattered light from micron-scale particles passing through a small volume within a 2D ring where three linear-fringe-structured illumination laser sources overlap in an 3D illumination pattern.

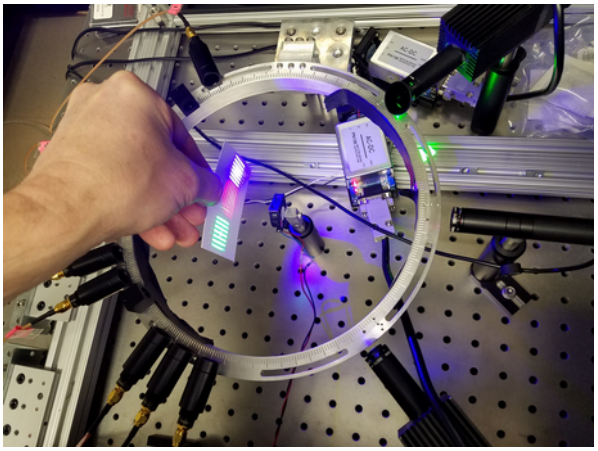

Figure 1: GraVeTAS laboratory instrument with business card showing structured light orientation of the three laser sources.

Particle Velocimetry: Three unique laser wavelengths are used for each orthogonal direction in order to enable simultaneous measurements of the velocity components. The temporal oscillation of the amplitude of the collected scattered light (see Figure 2) due to particles passing through the illumination fringes provides a direct measurement of the velocity components of the particle by dividing the measured spatial period of the fringes by the time between adjacent amplitude peaks.

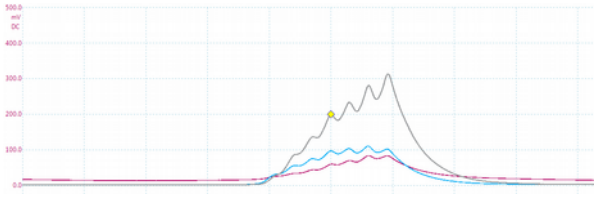

Figure 2: Three channels of time-series data using the velocity calibration source showing amplitude variation as the target object passes through the spatial fringes.

Particle Tomography: Based on long-established methods in the scattered light particle sizing literature, the scattered phase function of the particle is to first order proportional to the Fourier transform of the 2D projection of the particle in the direction of the collimated laser beam. By sampling the scattered field at a small number of set angular locations in a plane, a measure of the spatial scale in the plane may be calculated with a discrete Fourier transform. We use this principle and measure the scattered light at up to 5 locations for each of the independent laser sources.

Instrument Modularity: At the Southwest Research Institute, we've adapted and tested the instrument for several velocity regimes (Brownian motion to 50 meters per second), distance demands (from 8 cm to 3 meters to the measurement location), and laboratory and field implementations. The cost of the instrument is extremely low by using low power multimode diode lasers, Si photodiodes, and commercially available processing systems that cost on the order of $100 to acquire and transform time-series data to velocity and size particle values.

Results: We will present the current implementations of the instrument along with the most recent measurements of the two modalities of the instrument; velocity and particle shape measurements. We compare our shape reconstruction results with measurements of particles under standard laboratory microscope images.